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JULY 15, 1991

CHEMICAL & ENGINEERING

NEWS

Scientists present latest in AIDS research at Florence conference
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Salary & Employment Survey

Recession raises joblessness among chemists, as salaries make routine gains
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CHEMICAL & ENGINEERING NEWS

Volume 69, Number 28
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JULY 15, 1991

News of the Week

■ **MIT researchers produce buckminsterfullerene in significant amounts in benzene flames, a discovery that may lead to alternative synthetic route to C_{60} and C_{70}.** **Page 6**

■ **Chemical companies tally and tout their progress in cutting toxic air emissions; Monsanto's ambitious efforts draw praise from EPA.** **Page 7**

■ **Senate panel votes to fund space station *Freedom*, despite last-minute appeal by coalition of scientific societies.** **Page 7**

■ **Single-molecule gates that control access to electrodes offer new possibilities for molecular recognition and selectivity in electrochemistry.** **Page 8**

■ **Former East Germany's chemical industry can be saved only by rapid privatization, billion-dollar investments, and drastic work force reductions, according to study by German agency Treuhandanstalt.** **Page 8**

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News Focus

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Business

Newly public Cygnus Therapeutic Systems teams with pharmaceutical partners to develop custom-designed transdermal drug delivery systems. **Page 23**

Government

Work on a comprehensive energy bill has started in Congress but likely won't be finished before year's end. **Page 26**

Legislation to expand the toxic chemicals list covered under Superfund right-to-know provisions is being readied in the Senate. **Page 28**

Science/Technology

Catalysis R&D detailed as pivotal to wide range of disciplines, during recent meeting of Catalysis Society. **Page 30**

NIST's advanced technology program is seeking proposals for generic technologies projects. **Page 33**

Books

"The Chemical Industry in the U.S.S.R.: Economic Geography" is long-needed reference work with historical perspective. **Page 40**

Salary Survey

Current recession has taken its toll on chemists, boosting joblessness significantly higher to 1.6%, ACS survey shows. Median salaries are up 4.4%, just about in line with inflation. **Page 35**

Chemical & Engineering News
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LETTERS

Business with Burma

Myanmar, known as Burma until June 1989, is an underdeveloped country rich in natural resources, although it has not always been this way. Prior to 1962, Burma was one of Southeast Asia's most progressive countries economically, socially, and educationally. It is home to the world's largest and most pristine teak forests, unmined gold, and sizable oil reserves.

From 1962 until today Burma has been closed to the outside world. After September 1988, most countries providing assistance to Burma suspended their aid (both humanitarian and nonhumanitarian). With the advent of widespread international condemnation of the actions of the Burmese government, many companies have since entered into business relationships with Burma. Why? What provoked so many nations of the world (including the U.S., Canada, U.K., and Japan) to severely curtail or eliminate assistance programs with Burma? Yet why are so many companies now engaged in dealings with Burma, a trend inconsistent with the majority of the international community? Finally, what concern is any of this to the members of the American Chemical Society in particular, and the chemical community in general?

In order to gain an understanding of what's at stake, one needs merely to take a glimpse at Burma's contemporary political and social situation. After 25 years of repressive military rule, a prodemocracy movement achieved widespread support and called for free and fair elections, the restoration of civil and political liberties, and an end to constitutional dictatorship. In August 1988 a nationwide peaceful demonstration was held only to be met with large-scale killings of demonstrators by the Burmese Army. At least 3000 students, civilians, and Buddhist monks were killed by the Army during the summer of 1988.

Outraged by the military's blatant disregard for human rights, the international community suspended assistance programs with Burma. Facing a financial crisis due to the abrupt withdrawal of aid from foreign governments, the Burmese government began selling rights to foreign companies for on-shore oil exploration. Despite the denouncement of Burma's human rights violations by many nations, several companies from around the world signed contracts with Burma's military government—including Amoco and Unocal from the U.S. and government-owned Petro-Canada (despite the Canadian government's official denouncement of Burma's human rights violations).

Under burgeoning public pressure, the military government announced that parliamentary elections would be held in May 1990. To the government's astonishment and dismay, the people of Burma voted the military government out of power (democratic representatives won over 80% of the Parliament seats). Despite the unambiguous election results, the military refused to hand over rule to the newly elected representatives. A large number of representatives were arrested and imprisoned. Recently, the military junta signed a $1 billion arms deal with China, a pact that is said to include chemical weapons (an allegation Burma staunchly denies). Meanwhile, Burma's colleges remain closed and most children are denied an education. Human rights violations continue by the hundreds, as does condemnation by most governments of the world. Thus, it appears that petrochemical investments strengthen the position of Burma's military regime without benefiting the general population.

Petrochemical companies are among the most publicly visible elements of the chemical community and, indeed, the business community worldwide. Chemists and chemical engineers already suffer from a dismal public image due, in no small part, to environmental disasters

Corrections

- June 24, page 4: The chemicals used to produce Antiblaze 19, a flame retardant manufactured at the Albright & Wilson Americas plant where an explosion occurred, are trimethyl phosphite, dimethyl methylphosphonate (DMMP), and trimethylolpropane (TMOP) or 2-ethyl-2-(hydroxymethyl)-1,3-propanediol. TMOP was incorrectly identified as trimethyl phosphate.
- June 24, page 84: The base allotment for local sections in 1992 will be $3020, not $3030, resulting in a total allotment for all sections in 1992 of $1,013,600, instead of the reported figure of $1,017,472.

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Recession Raises Joblessness Among Chemists, Salaries Post Routine Gains

Latest annual ACS survey shows 1.6% of respondents were unemployed earlier this year and salaries have risen to median of $52,000

Michael Heylin, C&EN Washington

The 1991 annual salary and employment survey of ACS members confirms the considerable impact the current recession has had on the job market for chemists. On March 1 this year, the date of the survey, 1.6% of respondents were jobless. This was significantly higher than the 1.0 to 1.1% level of the previous four years. It was the highest level of chemists unemployed, but seeking employment, since 1986, when it was 1.7%. More than 40% of those unemployed on March 1 had been jobless for more than six months.

The new survey also indicates that salaries for the chemistry profession overall advanced to a median of $52,000 for those working full time. This was up 4.4% from the $49,800 median for the 1990 survey. As in recent years, this gain was just about in line with inflation. The consumer price index for wage earners rose 4.6% between March 1990 and March 1991. Individual chemists, who all gained an extra year of experience and some of whom earned promotions between the two surveys, did better. They apparently posted an average salary gain of somewhat more than 6% for the year.

The median salary is that which is exceeded by 50% of survey respondents. It is used because it is not affected by a few extremely high or low cases and so more accurately reflects the typical salary than does the mean. All salaries quoted in this article are for chemists employed full time. They represent the base annual salary from a chemist's principal job.

This year's survey involved sending questionnaires to a random sample of 17,000 ACS members living in the U.S. who were not more than 70 years old and neither students nor on retired status. The survey was conducted by ACS's Market & Business Analysis Department under the direction of senior research analyst Joan Burrelli.

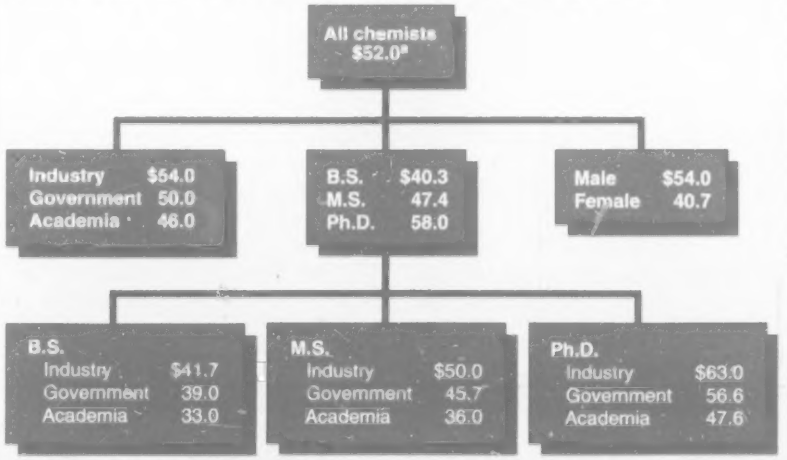
More than 9800 questionnaires were returned for a 58% response rate. Of those who responded, 56% held doctoral degrees, 19% had master's degrees, and 24% had bachelor's degrees. By race, 88.5% were white, 7.8% Asian, 1.6% Hispanic, 1.2% black, 0.4% American Indian, and 0.5% "other." By sex, 82% were men, 18% women. By employment, 62% worked for industry, 25% were academics, and 13% worked for government or in other nonacademic positions.

As has usually been the case, the unemployment rate for chemists has apparently remained markedly below other indexes of joblessness. This was certainly true of the 1.6% rate indicated for chemists in the latest survey. The unemployment rate for all civilian workers was at 6.8% in March this year, up from 5.3% a year earlier. Of those with a managerial or professional specialty, 2.5% were unemployed this March, up from 1.8% in March 1990.

It is not known how precisely the unemployment data obtained from these surveys of ACS members measure the level of joblessness throughout the chemical profession. However, year-to-year changes in the unemployment rates obtained from the surveys are at least strong qualitative indicators of shifts in the job situation for chemists.

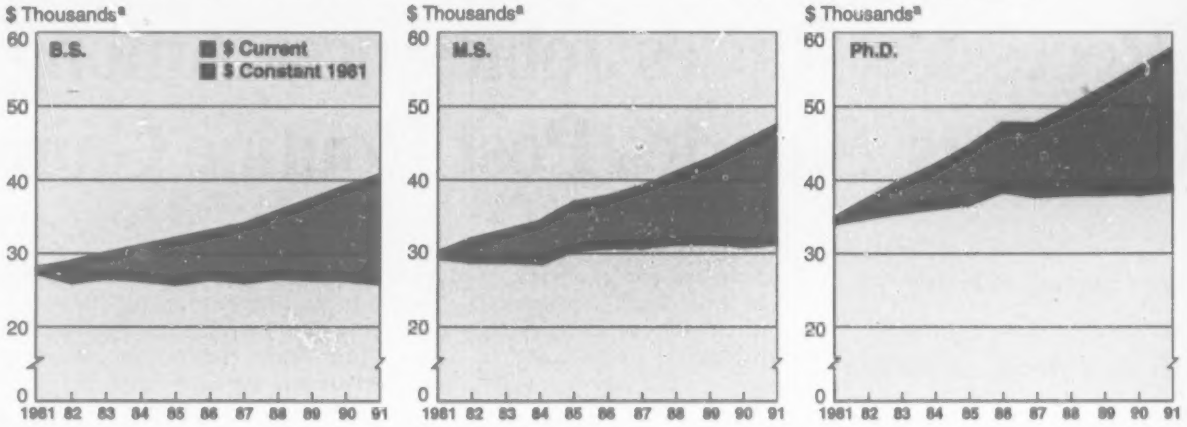
The jobless rate from the surveys hovers close to 1.0% during healthy economic times. It reached 2.2% in the recession year of 1983 and peaked at 3.2% during the more seri-

Male Ph.D. industrial chemists top the salary scale



a Median base annual salaries in thousands of dollars as of March 1, 1991. Source: ACS survey

Median salaries for Ph.D. chemists have risen faster than for their B.S. colleagues



Note: Average salary increases for individual chemists have been larger because of increasing experience. a Median base annual salary for chemists employed full time as of March 1 of each year. Source: ACS survey

Median salary of all chemists exceeds $50,000 for first time

$ Thousands	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981	Annual change 1990–91	1986–91	1981–91
CHEMISTS' MEDIAN SALARIES[a]														
B.S.	$40.3	$39.0	$37.0	$35.4	$33.5	$33.0	$32.0	$30.9	$30.0	$28.5	$27.5	3.3%	4.1%	3.9%
M.S.	47.4	45.0	43.0	41.0	39.0	37.9	36.0	34.0	33.0	31.6	30.0	5.3	4.6	4.7
Ph.D.	58.0	55.0	52.5	50.0	47.7	47.8	44.0	42.0	40.0	37.5	35.0	5.5	3.9	5.2
All chemists	52.0	49.8	47.3	45.0	42.5	42.5	40.0	38.0	36.0	34.7	32.0	4.4	4.1	5.0

a Base annual salary of chemists employed full time as of March 1. Source: ACS survey

Women chemists' salaries average about 88% those of male counterparts

Mean salary, $ thousands[a]	B.S. All chemists	B.S. Men	B.S. Women	B.S. Women as % of men	M.S. All chemists	M.S. Men	M.S. Women	M.S. Women as % of men	Ph.D. All chemists	Ph.D. Men	Ph.D. Women	Ph.D. Women as % of men
EMPLOYER												
Private industry	$46.5	$50.2	$40.3	80%	$54.2	$56.2	$50.1	89%	$68.6	$69.8	$65.7	94%
Academic	31.0	32.7	30.1	92	36.3	39.2	32.8	84	52.2	53.9	44.2	82
Government	40.3	42.9	39.1	91	46.8	48.2	43.7	91	59.4	61.1	51.9	85
Other	51.3	57.3	37.8	66	47.2	49.9	42.5	85	66.8	70.0	51.5	74

a As of March 1, 1991; to facilitate comparison, women's salaries are adjusted for the difference in average length of experience between them and men. Source: ACS survey

ous economic downturn for the chemical profession in 1972. The surge to 1.6% this year reflects the current less severe recession. Industrial chemists apparently have been the most vulnerable to joblessness lately, at 1.8% according to the latest survey, and academics the least, at 0.9%.

By recent job function, former general managers were the most likely to be unemployed, 2.4% as of this March, according to the survey. Teachers were the least likely, 0.7%. Research workers, at 1.5%, were just about at the 1.6% overall median.

Slow economic times also bring increases in both postdoctoral ranks and the number of chemists working part time. This is reflected in the latest survey. Chemists on postdocs or fellowships moved up to 2.6% of the total from a year-earlier 2.2%, and part time employees increased to 1.8% from 1.4%.

Women are particularly vulnerable to this trend in relatively hard times. For instance, the latest survey indicated that 4.2% of women chemists were employed part time, but only 1.2% of men worked part time. Women also were overrepresented in the postdoctoral ranks—3.0% compared with 2.5% for men. Overall, about 91% of women chemists were employed full time compared with about 95% of the men.

During the 12 months covered by the latest survey, 3.1% of chemists were unemployed at one time or another. Slightly more than half of them found new jobs within three

Years of experience is the major determinant of salary level

Median salary, $ thousands[a]	Years since B.S. degree									Overall median
	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more	
ALL CHEMISTS	$30.1	$38.0	$47.5	$52.0	$58.0	$61.0	$60.7	$64.0	$66.0	$52.0
By sex										
Male	32.0	40.0	48.2	53.3	60.0	63.0	62.3	66.1	66.7	54.0
Female	29.6	36.0	42.7	45.0	46.0	45.0	50.0	42.6	49.0	40.7
By degree										
Bachelor's	30.0	35.0	42.0	46.6	50.7	51.5	52.0	60.0	59.0	40.3
Master's	—	37.0	44.9	49.6	52.0	49.4	53.2	55.0	62.5	47.4
Doctor's	—	47.0	51.0	56.0	61.3	65.0	65.5	68.0	69.9	58.0
By employer										
Industry	31.0	40.0	50.0	56.0	62.3	68.3	70.0	73.8	68.0	54.0
Government	—	35.0	40.6	45.7	52.4	55.5	56.3	57.5	—	50.0
Academia	—	31.6	37.0	40.0	43.4	48.1	54.1	54.6	60.7	46.0

a As of March 1, 1991. Source: ACS survey

months. But one fifth were unemployed for more than six months. Most affected were women chemists, 5.2%, and B.S. chemists, 4.5%. These figures were little changed from 1990 survey data.

This year's questionnaire asked chemists if they thought they are underemployed. Twenty-two percent responded yes. The range was from 18% for Ph.D.s to 28% for B.S. chemists. Of those who agreed they are underemployed, about half indicated they would prefer a more challenging position. Others noted their current position was not commensurate with their training or experience. About 7% of all respondents indicated they were looking for a new position.

The salary data in the new survey confirm once again what has been known for a long time—that the biggest single determinant of chemists' salaries is experience. Other critical factors are degree level, type of employer, managerial role, and gender.

To illustrate the importance of experience, in the 1991 survey the median salary for senior chemists from 30 to 34 years beyond their B.S. was $60,700. This was 60% higher than the median of $38,000 for chemists 25 years their junior with just five to nine years beyond their undergraduate degree. This large differential is partly due to the substantially higher percentage of Ph.D.s in the older group, 67%, than in the younger, 36%.

In industry managers have clear salary advantage

Median salary, $ thousands	By degree		
	B.S.	M.S.	Ph.D.
R&D management	$60.3	$65.0	$76.1
General management	53.7	62.0	78.0
Marketing	43.2	53.8	64.5
Applied research	42.0	48.4	58.0
Production	38.0	46.0	56.0
Basic research	36.0	44.7	60.0

a As of March 1, 1991. Source: ACS survey

However, even within the same degree level the salary differential for the 25 years of extra experience is still very substantial—around 45%. For B.S. chemists in the two groups the difference is 49%, $52,000 compared with $35,000. For M.S. chemists the difference is 44%. For Ph.D.s it is 39%.

For most of their careers, Ph.D. chemists earn between about 20 and 25% more than their B.S. colleagues of the same age. The median salary for all Ph.D.s is $58,000, some 44% higher than the $40,300 median for B.S. chemists. This extra differential is largely due to the dominance of chemists with Ph.D.s in the higher paid, older groups.

In the 1991 survey, B.S. chemists represent only 12% of those 35 to 39 years beyond their undergraduate degree. This compares with 46% of the five-to-nine year group, and reflects the fact that older B.S. chemists are more likely to leave ACS than are their Ph.D. colleagues. However, older B.S. chemists who do retain their society membership apparently do quite well, with median salaries within about 15% of those of their Ph.D. contemporaries for the closing years of their careers.

Full professors at Ph.D.-granting schools average $80,000

Median salary, $ thousands[a]	9–10 month contracts		11–12 month contracts	
	Non-Ph.D. school	Ph.D. school	Non-Ph.D. School	Ph.D. school
Full professor	$47.2	$60.0	$69.6	$80.0
Associate professor	36.8	44.4	54.4	53.0
Assistant professor	31.5	36.0	40.0	42.9

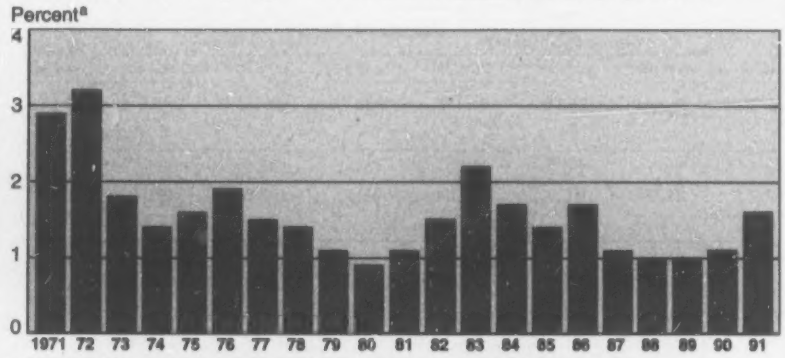
a As of March 1, 1991. Source: ACS survey

Chemists augment salaries with other income

$ Thousands	Salary[a]	Other[a,b]	Total[a]
B.S.	$40.3	$1.7	$42.0
M.S.	47.4	1.1	48.5
Ph.D.	58.0	2.0	60.0
All chemists	52.0	1.5	53.5

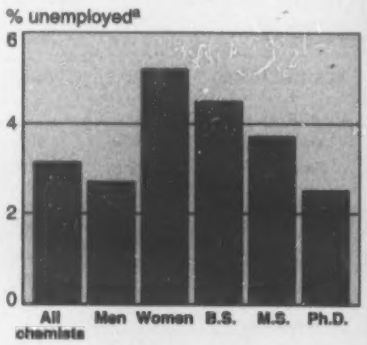
a Median value as of March 1, 1991. b Includes only other professional income. Source: ACS survey

Chemists' unemployment still below earlier recessions

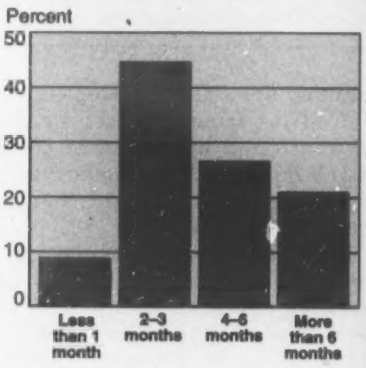


a Unemployed, but seeking employment, as of March 1 each year. Source: ACS survey

3% of chemists were jobless sometime last year . . .



. . . almost half of them for more than three months



a Excludes chemists who were not employed but not seeking employment. Source: ACS survey

Industrial chemists apparently have a salary advantage over their colleagues in academia. Despite the fact that relatively fewer industrially employed chemists are Ph.D.s, about 50% compared with about 90% of academics, the 1991 survey indicates a median salary for industrial chemists of $54,000, considerably higher than the $46,000 median for academics. Government chemists fall right between at $50,000. However, it has to be remembered that more than 60% of academics are on nine- or 10-month salary contracts and are often able to augment their income during the summer months.

Those that reach the top of the academic profession—full professors—receive competitive salaries. The median for full professors on 11- or 12-month contracts at Ph.D.-granting institutions is $80,000. At non-Ph.D.-granting institutions it is $69,600. These salaries are about 80% higher than those for assistant professors.

For chemistry faculty members who are on nine- or 10-month contracts, salaries are, as would be expected, substantially lower. For full professors at Ph.D.-granting schools the median is $60,000; at non-Ph.D. schools it is $47,200. Assistant professors on such shorter contracts post a median salary of $36,000 at graduate schools and $31,500 at non-Ph.D.-granting institutions.

In industry the bigger salaries are in management. For instance, Ph.D.s working in general management had a median salary of $78,000 in the latest survey. For those in R&D management it was $76,100. These salaries compare with medians of $56,000 for Ph.D.s in production, and $58,000 for those in applied research.

Industrial chemists are at highest job risk

	% of chemists in category	% unemployed[a]
MOST RECENT EMPLOYER		
Industry	62%	1.8%
Academia	25	0.9
Government	8	1.2
Other	5	1.8
MOST RECENT WORK FUNCTION		
R&D	42%	1.5%
Teaching	12	0.7
R&D management	11	1.6
General management	8	2.4
Production	6	1.4
Other	16	1.6

a As of March 1, 1991; excludes chemists who are unemployed but are not seeking employment. Source: ACS survey

This advantage for those in management persists at other degree levels. For instance, M.S. chemists in R&D management have a median salary of $65,000, well above the $46,000 for M.S. chemists in production. Similarly, B.S.-level R&D managers' median salary of $60,000 is 67% higher than the $36,000 median for B.S.-level industrial chemists in basic research.

The median salary for male chemists in the 1991 survey is $54,000. This is 33% higher than the $40,700 median for their female colleagues. A significant part of this difference reflects the reality that, as a group, male chemists are older, more experienced, and more likely to hold an advanced degree.

However, substantial differences persist even when salaries are compared within degree levels and after allowance is made for the shorter experience of women. Burrelli has undertaken this analysis, calculating the mean salaries, by degree, for men and women in industry, government, and academia. On this basis, most women earn between 80 and 94% as much as their male counterparts. The overall average is about 88%. This situation has changed very little in recent years, except that today starting salaries for men and women with equal qualifications are essentially the same.

According to Burrelli, geographic location is not a major determinant of chemists' salaries. For instance, salaries for industrially employed Ph.D.s 10 to 14 years beyond their B.S. cluster closely between $50,000 and $53,000 throughout the country.

Some chemists supplement their salaries with other professional in-

Percentage of chemists employed full time at lowest level in seven years

Employment status[a]	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981
Employed full time	94.0%	95.2%	95.3%	95.4%	95.4%	94.8%	95.2%	93.7%	93.5%	94.9%	95.6%
Employed part time	1.8	1.4	1.5	1.6	1.5	1.5	1.5	1.7	1.7	1.4	1.1
Postdoctoral or fellowship	2.6	2.2	2.2	2.0	2.0	2.0	1.9	2.9	2.6	2.2	2.2
Unemployed	1.6	1.1	1.0	1.0	1.1	1.7	1.4	1.7	2.2	1.5	1.1

a As of March 1, 1991; excludes chemists who are not employed but not seeking employment. **Source:** ACS survey

Women and B.S. chemists more likely to be among the unemployed

	Chemists								
		By sex		By highest degree			By minority status		Chemical engineers
Employment status[a]	Total	Men	Women	B.S.	M.S.	Ph.D.	Minority[b]	Nonminority	
Employed full time	92.6%	93.5%	88.9%	93.5%	94.2%	91.9%	88.2%	93.2%	94.7%
Employed part time	1.8	1.2	4.2	2.1	2.0	1.5	0.6	1.9	0.9
Postdoctoral or fellowship	2.6	2.5	3.0	0.1	0.1	4.3	8.0	1.9	0.7
Unemployed									
Seeking employment	1.6	1.5	1.9	2.0	1.7	1.3	2.5	1.4	1.3
Not seeking employment	1.5	1.3	2.0	2.2	2.0	1.0	0.7	1.5	2.4

a As of March 1, 1991. b Black, Spanish/Hispanic, American Indian, Alaskan native, Asian, Pacific Islander, or other. **Source:** ACS survey

come, but generally to a modest degree. For all chemists the median of such extra income is $1500 per year—somewhat less for government chemists, somewhat more for academics. For M.S. and Ph.D. academics the median is closer to $4000. Such supplemental income includes consulting fees, bonuses, earnings from a second job, overtime, and income from summer teaching.

ACS's salary surveys do not directly measure average year-to-year salary changes for individual chemists. The surveys are based on random samples of ACS membership, not the same sample every year, and the questionnaire asks only the salary as of March 1 of the current year. It does not also ask what the salary was one year earlier.

The surveys measure the increase in salaries throughout the profession year-to-year. But they do not measure the salary profile of individuals as they move up through the profession gaining experience and, in many cases, increasing responsibilities.

To illustrate the point, the 1981 survey indicated that B.S. chemists 10 to 14 years beyond their graduation then received a median salary of $27,000. In the 1991 survey, B.S. chemists with this amount of experience received a median salary of $42,000. This represented a 4.5% average annual gain over the 10 years, more or less in line with inflation. However, by 1991 those who had been in the 10- to 14-year group in 1981 had moved to the 20- to 24-year group in 1991 with a median salary of $50,700, for a 6.5% average annual gain for the decade.

As another example, in the 1981 survey, Ph.D. chemists 10 to 14 years beyond their B.S. posted a median salary of $30,000. By the 1991 survey this cohort had moved to the 20- to 24-year group with a median salary of $61,300. This represented a 104% increase over the decade for an average annual gain of 7.4%.

This type of analysis indicates that over the past decade, when the cost of living has increased an average of a little more than 4% per year, B.S. and M.S. chemists have posted annual salary gains that have varied from about 8% for those early in their careers to about 5% for their older colleagues. For Ph.D.s the gains have clustered more closely in the 6 to 7% range with less variation with age.

The latest annual salary survey of the membership of the National Society of Professional Engineers also brings out this difference between the rate of growth of salaries professionwide and of individual salaries. In this survey respondents were asked to provide both their current salary, as of Jan. 1 in this case, and the size of any salary increase during the previous year. Survey data indicate the median income of all engineers rose 2.7%, from $55,500 to $57,000, for the year. However, engineers who had not changed jobs and who had not been promoted received an average salary increase of 5.7%.

The 1991 survey asked academics what they did with their working time. Fifty-five percent indicated they spend half or more of it teaching, 37% devoted their time primarily to research, and 8% spent half or more of their time on administration. Only 18% indicated they spend less than a quarter of their time teaching.

A complete presentation of the data from this year's ACS survey, "Salaries 1991," will be available next month at a price of $150 per copy. It can be purchased from the ACS Distribution Office, Room 210, American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036. Questions or comments on the survey should be directed to Joan Burrelli at (202) 872-4433. □